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PROJECT HYAC II

Progress Report No. 4

31 August 1958 - 31 October 1958

SDR-9103-4

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PROJECT HYAC II

PROGRESS REPORT NO. 1

31 August 1958 - 31 October 1958

1.0 INTRODUCTION

This report covers progress during the two-month period of September - October 1958. Considerable effort went into project planning during this reporting period, resulting in a revised delivery schedule and a proposal for a definitive contract.

The Environmental Test Facility (ETF) is nearly completed at ITEK, Waltham, and is expected to be in operation in early December. A detailed test program is currently being formalized which is intended to be a working document to be used by those concerned with camera testing and test result evaluation. It will include the over-all philosophy of the test program and the detailed performance specifications for the camera and the cassette. These will include acceptance test specifications as well as environmental test specifications. The test program report will delineate the tests to be performed and the procedures to be used for camera qualification which will begin in January and is estimated to last for approximately two months. Qualification will then be followed by a second phase of testing for reliability and life. During qualification, the airborne units will be subjected to environmental conditions which are considered minimum for flight. During the second phase of testing, these conditions will be made more severe for the purpose of finding weak areas in the construction and design.

The HYAC lens cell assembly has been given vibration, shock, altitude and temperature tests. Additional thermal tests are being planned for the lens assembly.

2.0 PHOTOGRAPHIC SUBSYSTEM

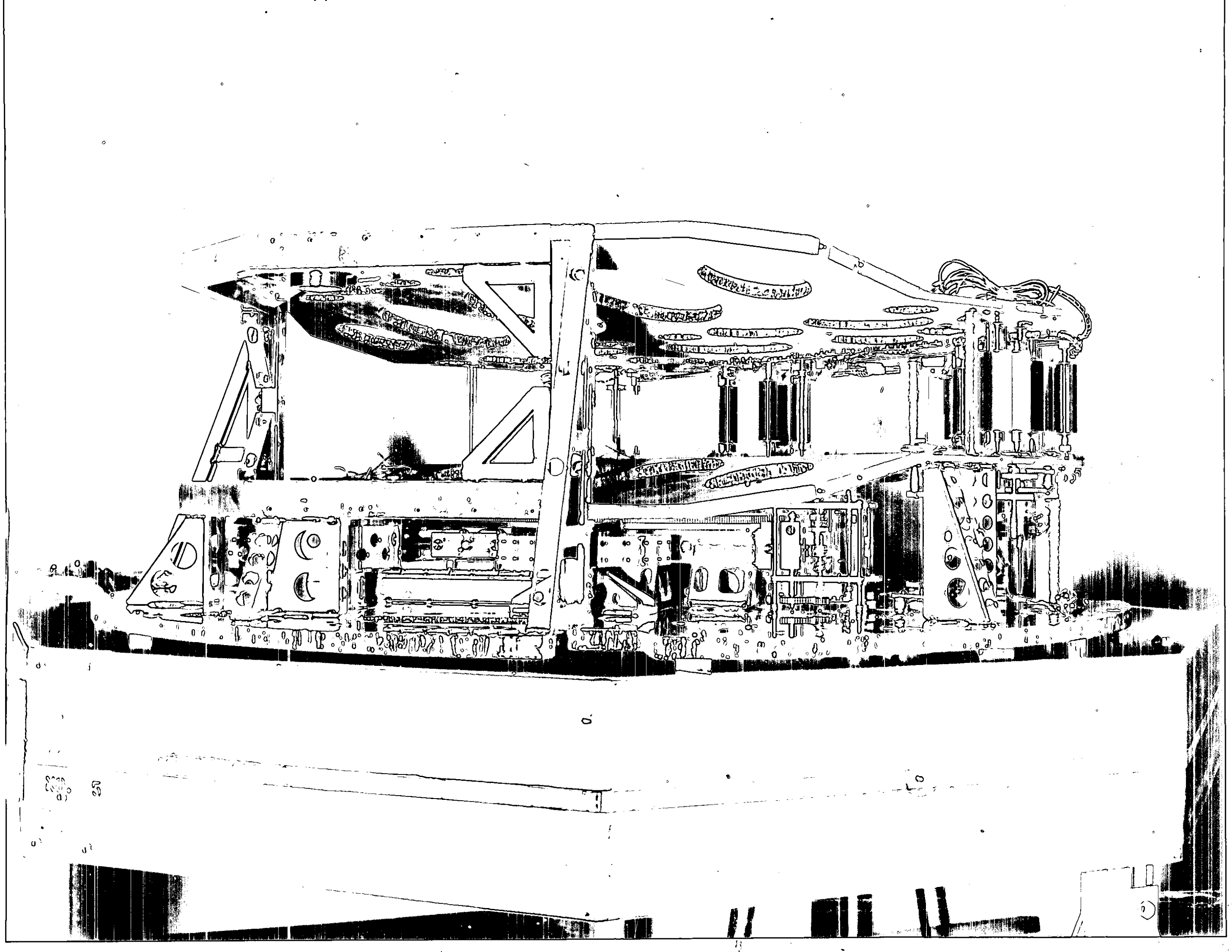
After completion of the first HYAC II lens in September 1958, the optics were installed in the beryllium lens cell and thermal tests were performed. These thermal tests utilized a titanium bar for holding the proper focal plane dimension relative to the lens nodal point. During these tests, it was conclusively proved that a satisfactory degree of temperature self-compensation was achieved in the design. These tests and the details are described elsewhere in this report, but it is significant to note that for a given temperature change of the entire lens-camera assembly, the change in air space between the first and second elements of the lens whose dimension is held by the beryllium cell, tends to lengthen the effective focal length approximately the same amount that the titanium plate lengthens the distance between the nodal point and the focal plane. Test results indicate that between 30 and 40 per cent of this focal shift is compensated for. For this reason, it is felt that, at this time, a temperature tolerance of ±10° from the 70°F nominal will be acceptable as a camera-performance requirement. It should be noted that this is based on the beryllium cell and the titanium plates both having a temperature change of the same sign. If, however, the change from nominal temperature is the opposite for the cell relative to the tianium plate, then the effect will be doubled. Initial data, using the thermal mock-up of the camera and cassette in the vehicle mock-up in tests performed by the prime have confirmed that these temperature limits are reasonable to expect during flight. The present thermal problem regarding focus seems well in hand due to camera ambient temperature changes.

Tests are being conducted to determine the effect of a radial gradient on the filter cell. If a significant gradient exists, then the filter cell which is normally a parallel plane develops a curvature and some power which in turn has the effect of changing the focal length. If large gradients exist, this could be a major problem. At the present, tests are being conducted to determine the magnitude of this temperature gradient.

An additional thermal problem developed and was solved during this reporting period. Originally, the camera, when shut off after its photographic run, did not stop in any particular location in scan. There was a possibility, therefore, of film burning or at least scorching and drying out, causing film breakage, if reflected sunlight entered through an open slit and was imaged on the film plane. This potentially serious situation has now been rectified by having the camera shut off only on the return sweep when the slit is closed. This was accomplished by the addition of only one wire which meant essentially no weight penalty.

2.1 CAMERA

Significant progress has been made in camera fabrication. It is expected that the first unit will be completely assembled by the end of November. This unit will contain all telemetry transducers for in-flight instrumentation, including the 13 temperature sensors on the camera and three on the cassette. It will not have the thermal gold plating, however. The second unit has been gold plated and will be identical to subsequent flight units in every way. See Fig. 1.



Approved For Release 2008/12/03 : CIA-RDP74B00752R000100310001-1

Fig. 1 First Camera Partially Assembled

The film transport mock-up was operated successfully in the altitude chamber at ITEK during this reporting period. This test duplicated the operational cycle including use of a real time scale for the tests. During a second phase, the tests were repeated with no film breakage and a full spool was successfully transported. Additional tests were conducted using the film transport mock-up to determine the effect on the emulsions of pressure sensitivity caused by the beaded rollers. A projector was arranged to image an aerial scene on the actual platen in the mock-up. The chamber was placed at altitude, given an adequate soak, and the film transport operated with aerial scenes imaged on the film. After processing, no pressure marks were noted in the aerial scene itself and only a very slight pressure marking was noted in a constant density exposure zone on the film. It was noted that the current beaded roller design which lowers the bead pressure on the film, and the reduced tension in the film drive system considerably alleviated this pressure marking problem. It was observed also that the pressure marking was less severe at altitude, possibly because the film effecitvely becomes stiffer and does not allow the beads to distort it as much. It is felt that the present design is adequate and that pressure marking will not be objectionable in actual operational photography.

Additional details of the pressure sensitivity tests together with static tests results and minimum roller size are reported in the Film Tests section of this report. Additional camera details are reported in the FCIC report enclosed as Appendix I.

2.2 CASSETTE

Three Ruge BN5-2 resistance thermometers will be placed in the cassette for temperature sensing. Two are located on one side plate on the roll axis, one forward near the motor, and one aft. The other is located near the film roller bracket on the opposite plate. All six cassettes delivered for tests have been fully instrumented with the required telemetry transducers. These tests will also include small film samples in holding fixtures for light leak detection during the tests. Since even extremely small light levels will cause fogging of the film, this is the only feasible means of light leak detection. An exposure of 5×10^{-3} meter candle seconds for SO 1188, or 5×10^{-2} meter candle seconds for SO 1221, is sufficient to cause a perceptible density increment of .05 over base density.

Since light leaks are an essential part of the [illegible] cassette tests, it would be desirable to have an ITEK field service engineer install these detectors and remove them after testing to insure proper handling techniques are used. Unless one can be absolutely sure that these detectors were not pre- or postexposed, the light leak tests are of no value.

2.3 TEST AND CHECKOUT CONSOLE

The first of three deliverable T & C.O. consoles has been completely assembled. In the interest of reducing costs, the fourth unit to be retained by FCIC will not be assembled.

It should be understood that because of recent changes in instrumentation requirements, the T & C.O. console will not completely simulate the vehicle electrical interface. In particular, the T & C.O. console will not provide minus 28 volts D.C. to the camera and as a result, will read temperature signals with only half sensitivity. Furthermore, neither of the two calibration voltages will be read by the T & C.O. console since this would serve only to check on the level of the voltage geing supplied by the T & C. O. console.

The T & C. O. console is not designed to operate compatibly with vehicle power, but is intended to replace the electrical interface of the vehicle. However, a simple modification can be effected to make the two compatible.

2.4 LENS

The first HYAC II lens was completed and ready for shipment on 11 October . However, a lens was not actually shipped to FCIC until 29 October. This delay was a compromise between FCIC's need and ITEK lens test requirements. During this time, pressure and thermal tests were conducted. This first delivered unit, although it met resolution requirements, was beyond tolerances in focal length. To alleviate this condition, an air space was changed to adjust the focal length, and the aspherizing operation, which was needed to bring the resolution back up to acceptable valves, was eliminated. This compromise was necessary to supply FCIC with a lens to be assembled in the first non-deliverable camera for compatibility testing. This lens can be returned at a later date for further aspherizing to improve the quality.

The first HYAC II lens, which will be retained at ITEK for environmental testing was completed. It appears that subsequent FCIC lens assembly need-dates can be met.

2.4.1 OPTICS

After assembly of the first HYAC II lens, a design error was discovered which produced a lens which could be improved. At this point, it was decided that the first design would be designated the HYAC IIA and the redesign the IIB. At present, it is felt that the IIA design will have the following minimum tangential or radial lens-film resolution on SO 1221 emulsion.

	LEFT		ON AXIS			RIGHT	
Angle Off Axis	2-1/2°	2°	1°	0°	1°	2°	2-1/2°
Resolution in Lines/mm	60	75	90	110	90	75	60

ACROSS SLIT

In the IIb design 100 ll/mm or greater is expected across the slit.

The IIb design is almost complete and glass for six units has been ordered. The present plan calls for fabrication of a total of eleven IIa lenses with sufficient glass on hand for a total of 15 units. This includes 14 for cameras (12 flight and 2 test units) and one lens for environmental test. The IIb lenses will be put in the last four flight cameras and possibly the last six.

2.4.2 CELLS

All cells are planned to be fabricated from beryllium with magnesium filter cells. The first five IIa units are now on hand in various stages of completion. There appears to be no delivery problems due to the use of beryllium. It will be necessary to redesign the cells for the IIb lens but it is planned that they will be mechanically similar and thus not in any way cause camera design changes. They will be replaceable with the IIa in fabrication although perhaps not in the field. At present, no retrofit program is planned. The total weight of the lens-filter-cell assembly is 8.8 lb. The C.G. is 1.224" toward the filter from lens nodal point. See Fig.2.

2.4.3 PRESSURE TESTS

A test fixture using a 110-inch f/10 collimator folded by means of two mirrors to fit into the 4' x 4' x 6" environmental chamber was made to conduct pressure tests with the HYAC lens. A test target and light source were fixed to a micrometer type stage at the focal plane of the collimator. The stage, with target, was motor driven and could be moved through focus of the collimator in steps of 0.020 inches.

A 24" HYAC IIA lens was mounted on a titanium plate with a remotely-operated 35 mm camera body and shutter assembly located in the focal plane. The HYAC lens used for this test had not been aspherized and was stopped down to f/12 to improve image quality. As a result, depth of focus was approximately $\pm$ 0.002 inches.

As the same variables affect the collimator and the lens, it was first necessary to determine temperature and pressure shifts in the collimator alone.

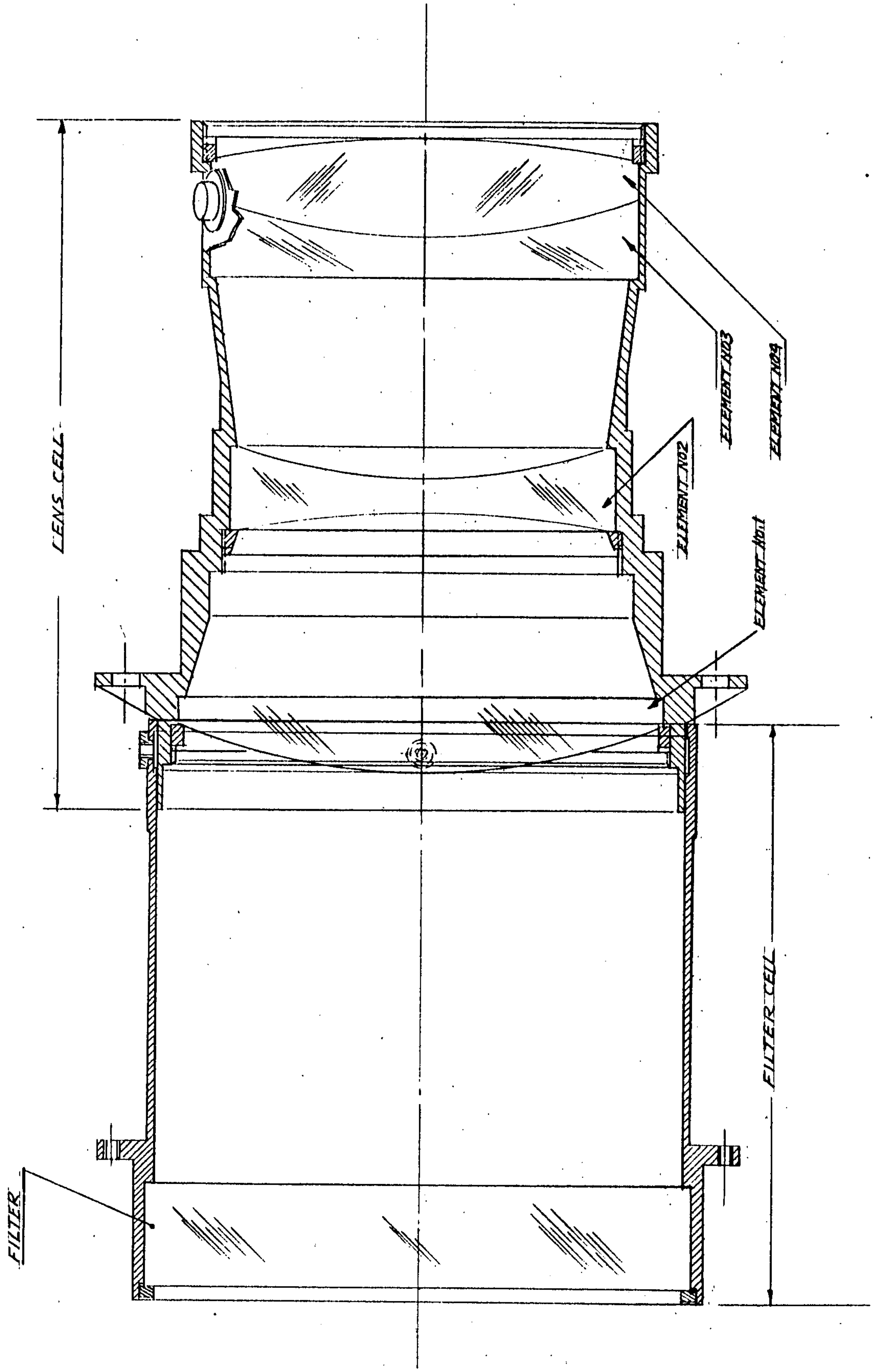

ELEMENT NO3
ELEMENT NO4
LENS CELL
ELEMENT NO2
ELEMENT No1
FILTER CELL
FILTER

FIG 2

Pressure Test

The lens focus was determined by making a through focus shift of the collimator target in steps of 0.020" at sea level pressure and 70° F temperature. The chamber pressure was then reduced to 1 mm Hg. and another through focus run made. Thirty-one pictures were made for each run, equivalent to 0.600 inch total shift of the target position in the collimator or approximately 0.30 inches total shift of the HYAC lens focal plane. The shift due to pressure change determined by these tests was found to be 0.021". The computed shift for the lens from atmospheric pressure to absolute vacuum is 0.023 inches.

Change in focal position of the HYAC lens was determined by introducing a shift in the target position of the collimator. The shift is equivalent to the ratio of the two focal lengths squared, i.e., for a shift of 0.021" in the collimator, the HYAC lens will shift approximately 0.001". Small errors in determination of the collimator focal position can be tolerated without necessarily affecting the test results, e.g., ± 0.005" in the collimator = ± 0.0025" in the lens.

All photographic data taken on this series of tests were made on Plus X Aerocon film. This is the standard base emulsion similar to SO 1188 film.

Maximum resolution obtained was 65-70 L/mm. The depth of focus was approximately ± 0.002". In all cases, a midpoint of the position of maximum resolution which was flat for a range of 0.004" was used in picking the best focal position.

After some modifications to the system, further tests on pressure and temperature effects will be conducted. In the latter tests, an effort will be made to separate the variables due to temperature. In addition, tests will be conducted with SO 1221 or SO 1213 type emulsions which will give higher peak resolution values and increased accuracy for small changes in lens focus.

2.4.4 Thermal Investigation

The following paragraphs describe the effects of temperature changes in the camera assembly from the specified design value of 70° F. Plates No. 2 and 3, making up sides of the camera which maintain the focal dimension, are fabricated of titanium sheets on aluminum honeycomb. The thermal expansion that will occur is due to the titanium cover sheets alone. As the focal length is 24", a shift of 1.2×10^{-4} inches per degree F is the anticipated change in the focal plane dimension. See Figure 5.

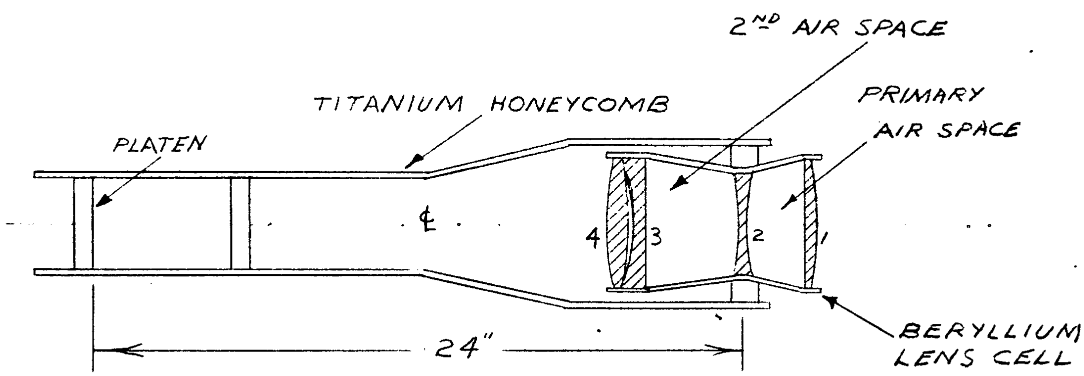
The lens cell is fabricated of pure beryllium. A change in temperature will cause a variation in the separation of air space between the lens elements.

An increase in temperature will thus result in a decrease in focal length which has an increasing effect to that which one gets from an increase in temperature of the titanium plates. The effective focal length of the lens will shift 0.00289" for each 0.001 inch change in the first air space dimension. See Figure 3 for a schematic illustration.

In the second air space from the center of the second element to the center of the third (approximately 4 inches), the effective focal length has a multiplication factor of about 0.00087 inches for each 0.001 inch change in air space dimension. This data is plotted in Figure 4 to show the variation of effective lens focal length and focal plane shift with changes in temperature from a 70°F ambient. The net out-of-focus change due to both the camera structure and the lens cell per unit variation of temperature (neglecting the thermal effects on the glass lenses) is approximately 2.0×10^{-4} inches per degree F. Looking at Figure 4 , the separation between the total beryllium lens cell and the experimental line (dashed) is probably due to the temperature effect on the glass in the lens. This includes both a change of index of refraction with temperature and a change in curvature of the glass with temperature, both having the effect of changing the lens focal length.

Some preliminary investigation was performed to determine empirically the overall thermal effects on the camera assembly. A mock-up, using a 24-inch titanium mounting plate and the lens in its beryllium cell was used. Twenty-four inches along the plate from the point of the lens cell mounting was a micrometer stage which had three directions of motion. On the micrometer stage is mounted a resolution target and a microscope. Behind the lens was a flat mirror so that the lens was auto-collimated. The micrometer stage was moved until the target and its auto-collimated image are in the same plane (the emulsion plane containing the target). The position of the auto-collimated image was determined by using the microscope which was fixed so that its focal point lay on the emulsion side of the target. The emulsion had been removed to give a clear view of the auto-collimated resolution target.

The entire apparatus was placed in an environmental chamber and then left to soak for 24 hours at each of the three temperature data points. Data was taken each time with good correlation. The consensus of this data is that there is a shift of focus of 8×10^{-5} inches per degree F, as plotted in Figure 5 , and captioned "Experimental".



SCHEMATIC
LENS AND CAMERA STRUCTURE

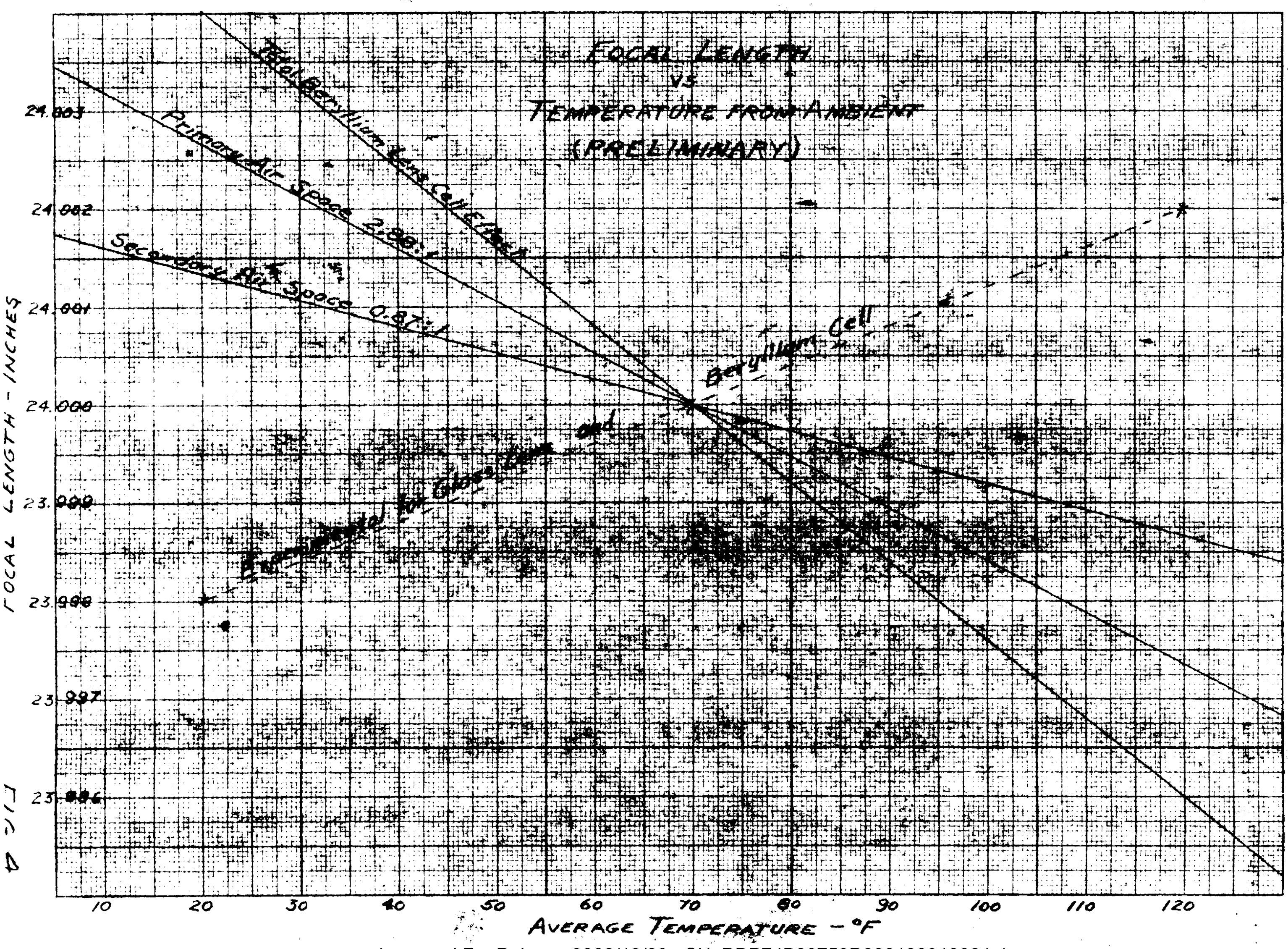

FOCAL LENGTH
VS
TEMPERATURE FROM AMBIENT
(PRELIMINARY)
Primary Air Space 2.88:1
Secondary Air Space 0.87:1
Beryllium Cell
24.003
24.002
24.001
24.000
23.999
23.998
23.997
23.996
FOCAL LENGTH - INCHES
10
20
30
40
50
60
70
80
90
100
110
120
AVERAGE TEMPERATURE - °F

FIG 4

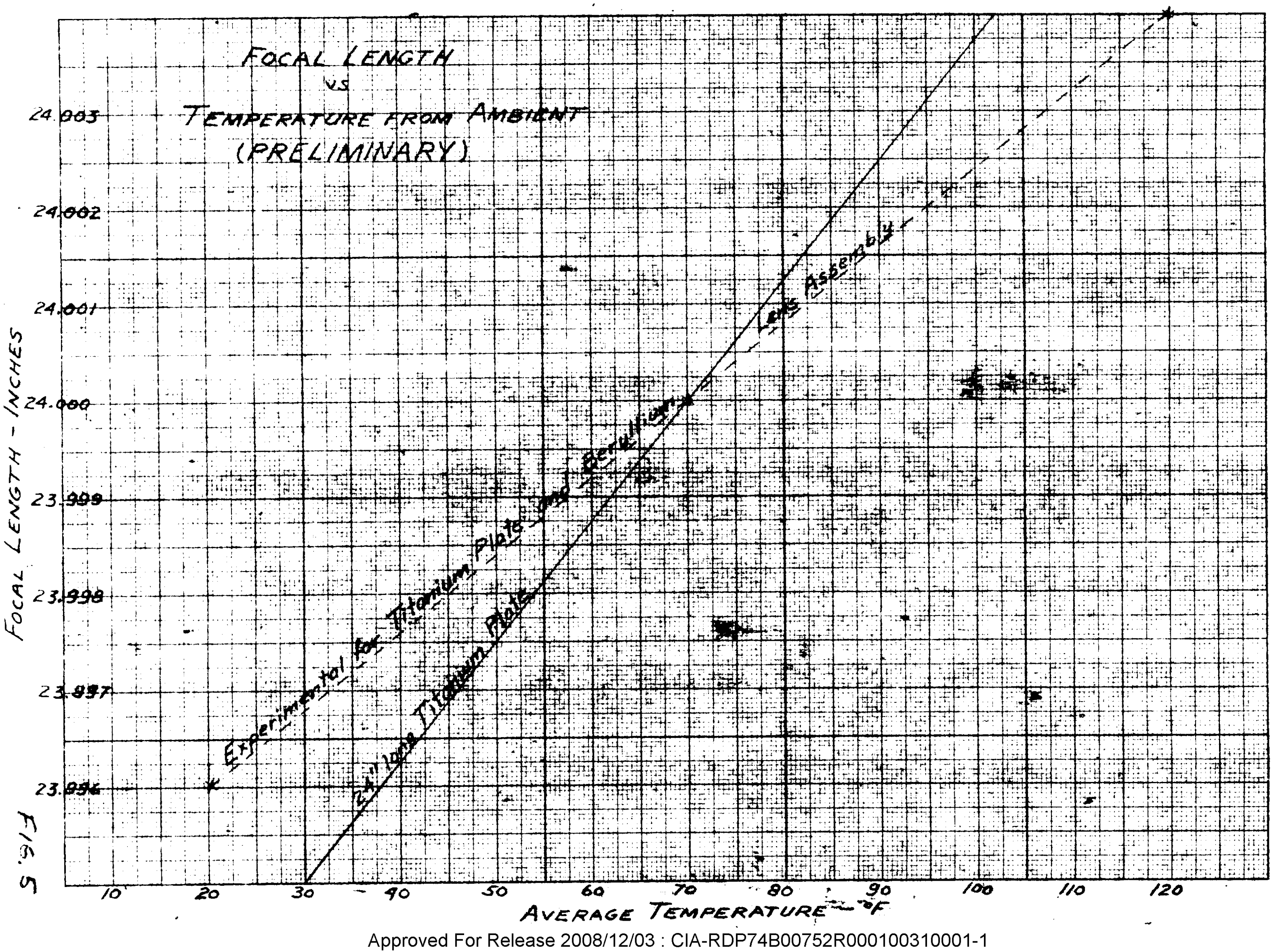

FOCAL LENGTH
vs
TEMPERATURE FROM AMBIENT
(PRELIMINARY)
Lens Assembly
Experimental for Titanium Plate and Beryllium
24" long Titanium Plate
24.003
24.002
24.001
24.000
23.999
23.998
23.997
23.996
10
20
30
40
50
60
70
80
90
100
110
120
AVERAGE TEMPERATURE ~ °F
FOCAL LENGTH - INCHES

FIG. 5

Both from this experimental data and from the analytical results, a temperature difference of 10°F can be tolerated from the mean set-up temperature which will be the amibent temperature for which the camera is to function operationally.

Additional thermal experiments are planned which will separate the temperature effects of the lens, the lens cell, and the camera structure, and confirm these preliminary results.

There are additional thermal effects on the film when the camera is inoperative. Because of the relatively high albedo of the earth's atmosphere and terrain, an investigation into the heating of the shutter and the film was made. The shutter will not have a temperature rise that will jeopardize the mission. It is expected to be 10-15° under the worst conditions, but the possible injury to the film was found to be marginal. The camera will therefore incorporate provision to stop only with the shutter closed on the return sweep and the film will not be continuously exposed to the re-radiation from the earth's surface.

Further, due to the possibility of radial thermal gradients that could be set up in the filter (glass has a high emissivity in the infra-red region), the camera will be stopped only in the return sweep position with the shutter closed. An experiment was conducted where the end of the lens cell surrounding the filter plus the filter face was deliberately exposed to a cold atmosphere. This cold atmosphere had a temperature of approximately -30° F. When a temperature change of the lens cell of approximately 10°F was established, there was a change in the focal plane of 0.005 inches. This focal shift was caused by the large thermal conductivity through the metal lens cell compared to the glass filter which caused a radial gradient to be set up instead of a gradient only along the axis of the filter. This data is indicative only of what temperature changes can do to the lens assembly if radial gradients are established.

From the data supplied to ITEK by the Prime, obtained in the simulated environmental test run No. 2, the over-all thermal problems appear to be within the range of being corrected by varying the emissivity of the surfaces inside and outside of the body of the vehicle. Until the prototype is tested under true conditions, no major changes of construction due to thermal requirements are anticipated.

2.4.5 LENS ASSEMBLY VIBRATION SHOCK TESTS

A dummy lens in a cell was taken through complete shock and vibration environment with no mechanical failure.

Data was taken on a HYAC II A lens and filter assembly prior to subjecting it to shock and vibration tests per the General Environmental Specification.

These data are shown below along with data taken after the tests:

RESOLUTION ACROSS SLIT

	LEFT 2°	ON AXIS 0°	RIGHT 2°
BEFORE TEST —	94/106	134/134	94/119
AFTER TEST —	89/119	119/134	94/119

TANGENTIAL/RADIAL RESOLUTION

IN LINES/MILLIMETER LENS/FILM (SO1221)

These data show essentially no effect due to testing. Additional evaluation and testing is planned.

2.5 FILM

2.5.1 FILM RESOLUTION MEASUREMENTS

As a part of the over-all question of image quality for the entire system, measurements were made of the high and low contrast resolving power of the two photographic materials of prime interest, EK SO-1188 and EK SO-1221, and, in addition, EX Micro-File (Type 5204).

These tests were made in the ITEK Resolving Power Test Camera, which employs a high quality condenser system to trans-illuminate a resolving power target. The image is formed with a Balter 17.5 mm focal length lens on the test emulsion, which is located precisely in the focal plane by means of a small aperture and pressure plate. A series of neutral density evaporated Inconel filters rotate on a turret to provide 21 discrete exposure changes over a log E range of 3.0 (1000:1). In addition, additional filters can be added to isolate a portion of the spectrum, or to make gross changes in the exposure level. The illumination is provided by a xenon flash lamp, operating from a modified power supply which provides exposure time of 1/250, 1/500, or 1/2000 second. Thus, there is little possibility that vibration can affect results at these short exposure times. The entire system is mounted on rubber vibration isolation pads.

On each of the four films tested, three exposures were made at each level, and since each picture contains two sets of lines, (vertical and horizontal) at each sixth root of two size change, there were six readings for each log E value to be plotted. The result of this averaging is to provide a much smoother plot of resolution versus exposure. It also tends to reduce the significance of the occasional exceptionally high reading which occurs. Test targets of 1000:1 and 2:1 contrast were employed.

Processing for the SO-1188 and SO-1221 was done in D-19 developer, for six minutes at 68F. The resulting gammas were 1.8 and 2.8, respectively.

RESULTS

In Figure 6 , resolving power is plotted against log exposure for EK SO-1188, EK SO-1221, and EK Micro-File (Type 5204). EK Plus -X Aerecan is not included since this film will not be used and measurements were made to check comparison with EK SO-1188 and the original EK SO-1166 film. Table 1 shows the peak values obtained for high and low contrast tests for each film.

The results obtained on EK Micro-File (Type 5204) indicate its possible use in aerial photography. This film requires much greater exposure but can provide high contrast resolution nearly 100 lines per millimeter greater than SO-1221. Micro-File, like SO-1221, remains very constant in resolving power for a wide variation for high exposure level but does have the disadvantage of not being of use for low exposure levels.

Peak Resolving Power Values at Optimum
Exposure for Four Films at 1000:1 and
2:1 Target Contrast

Film	High Contrast Resolving Power	Low Contrast Resolving Power
SO-1188	106 lines/mm	54 lines/mm
SO-1221	195 " "	145 " "
Micro-File	320 " "	190 " "

Note that the graph for SO-1221 shows an unusual leveling off for the high contrast resolving power at high exposure levels. This is a characteristic of this film type that provides better detail retention even in badly overexposed portions of the scene, and is related to the wide emulstion speed change that occurs with development time at a fairly constant gamma. Stated differently, this film has

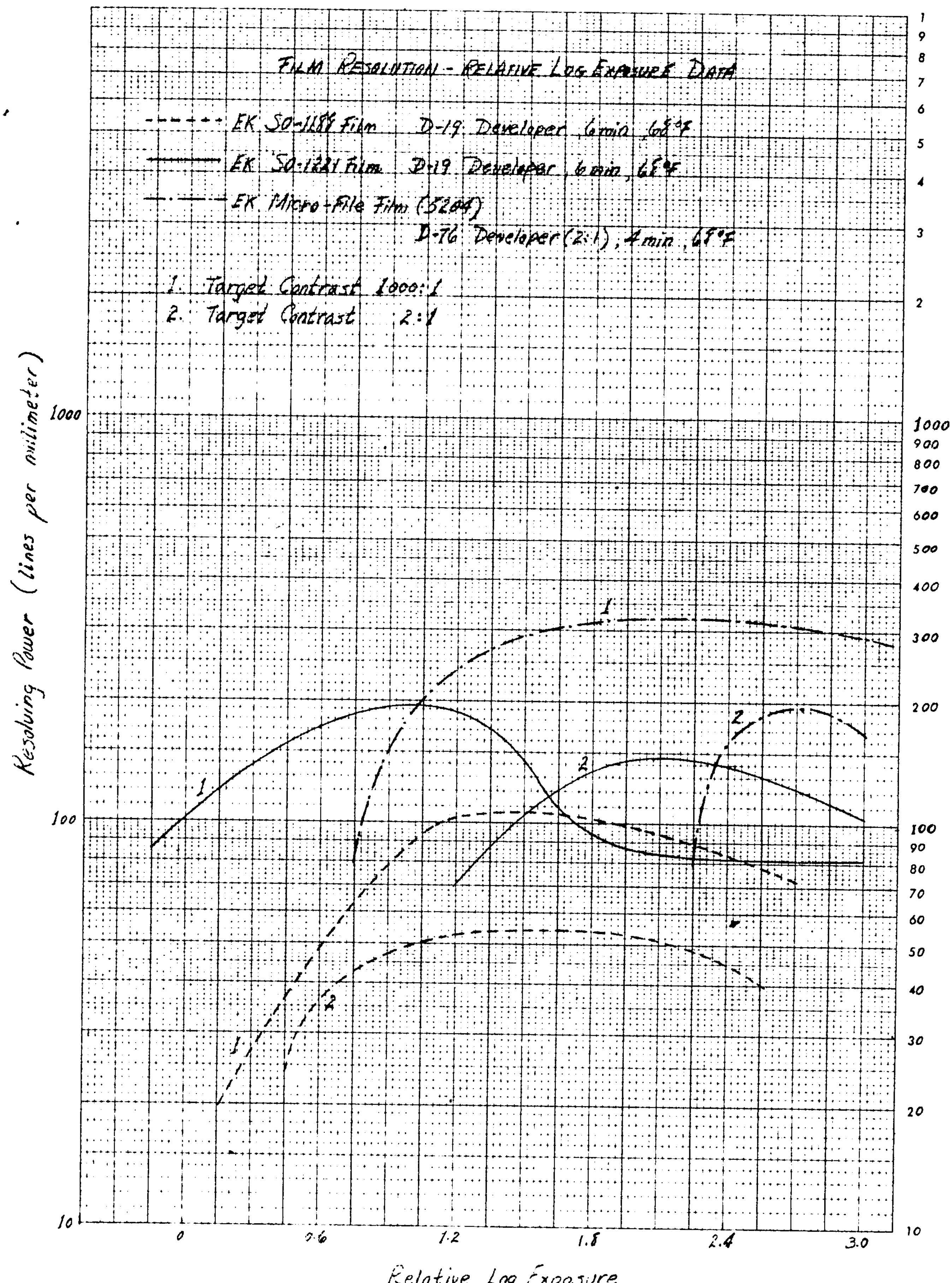

FILM RESOLUTION - RELATIVE LOG EXPOSURE DATA
EK SO-1188 Film D-19 Developer 6 min, 68°F
EK SO-1221 Film D-19 Developer 6 min, 68°F
EK Micro-File Film (5204) D-76 Developer (2:1); 4 min, 68°F
1. Target Contrast 1000:1
2. Target Contrast 2:1
Resolving Power (lines per millimeter)
Relative Log Exposure
0
0.6
1.2
1.8
2.4
3.0
10
100
1000

FIG. 6

an emulsion speed latitude that can be used in practice without severe changes in contrast, as opposed to most other aerial photographic materials. Note also that the SO-1221 shows a remarkably high level of performance even at the low contrast level. The low contrast value is about 75% of the high contrast value.

The results obtained on both the SO-1188 and Plus-X Aerecon films were low, based on the experience that was obtained with the original SO-1166 film that was the forerunner of the Plus-X Aerecon. Tests made under identical conditions on the SO-1166 film some two years ago yielded high contrast figures of at least 140 lines per millimeter. The decrease is startling. An explanation by EK representatives is that image quality has been sacrificed in the interests of maintaining other desirable properties, such as keeping stability. However, the serious change in image quality warrants a serious search into the possibility of reviving the level of quality originally obtained, even if other attributes of the film may suffer. Original resolution limits were made conservative, anticipating a comparison between the relative resolution of SO-1221 and SO-1188 emulsions. This data bears out the validity of those assumptions.

The low contrast figure of 54 lines per millimeter actually falls below the system requirement; it is hardly necessary to point out that if the emulsion itself under ideal optical test conditions produces less than 60 lines per millimeter, then in the complete reconnaissance system with other degradating factors such as vibration, image motion, and environmental changes potentially present, the final image quality will fall below the film capability. As an example, if the system minus the film is capable of 60 lines per millimeter, a calculation based on the reciprocal squared relationship which has been shown by O'Neill and others to provide a close prediction of the combined resolution, the result would be about 40 lines per millimeter.

2.5.2 FILM ROLLER TESTS

Tests have been conducted on two films, EK SO-1188 and EK SO-1221 to determine whether or not any photographic degradation is noticeable when the film is drawn over rollers of various sizes under ambient and simulated altitude conditions. In the initial design, a one-inch minimum roller size was selected for the camera, based on past experience. The film samples were exposed to a calibrated step wedge before being subjected to the test. Afterward, the samples were processed in standard solutions, the step densities read, and the D-log E curves plotted. A control strip was processed along with each sample.

Under all test conditions the deviation was slight enough to be within the range of experimental error. Local variations do not appear to indicate any significant trend as regards density change and resultant resolving power capabilty.

DESCRIPTION OF TESTS

1. General
   a. All tests were conducted on fresh 70 mm unperforated SO-1221 film.
   b. A two-pound weight was clipped onto the end of the sample before the film was drawn over the roller.
   c. The test apparatus consisted of a wooden frame which supported the rollers and the take-up spool
   d. All tests were conducted by splicing the sample onto a strip of similar material used as a leader which was attached to the take-up spool. The sample was drawn over the top roller once for each test. This top roller was ball bearing mounted and replaceable with various diameter rollers from 1/8" to 1".

2. Visual, qualitative tests
   a. Tests were conducted on 1/2", 3/4" and 1" diameter rollers under normal ambient conditions.

3. Tests under uncontrolled room environment
   a. Film samples were exposed on lb Sensitometer at 0.1 second with 78AA (daylight coversion) filter in place.
   b. Samples were tested over 1/4" and 1/8" diameter rollers.
   c. Samples were processed immediately along with a control strip not run over a roller. Strips were developed for 8 minutes in D-19 at 68°F.
      (1) Developing was done in a plexiglass bottle which holds 1200 cc of solution.
      (2) Sample and control were taped to opposite sides of a sheet of plexiglass attached to a rubber stopper which fits the bottle. Attention was given to keeping the high density end of both strips at the same end of the plexiglass sheet.

(3) The bottle was manually agitated by rotating it about the longitudinal and transverse axes intermittently (30 seconds per minute). When not being agitated, the bottle was set in a waterbath to maintain constant temperature. Film strips were fixed, washed, and dried together.

d. Three density measurements were made for each step on the Macbeth Transmission Sensitometer which reads directly in 0.02 increments and which can be estimated to 0.01. Normal tolerance for this instrument is 0.02 density units.

e. From these readings, D-log E curves were plotted for each test and control.

f. To determine the normal variation between two strips, a pair of control strips was processed and evaluated together.

4. <u>Tests under simulated high altitude environment</u>

a. Samples were exposed as under 3a.

b. Samples were tested by being drawn over a 1-inch diameter roller while the test set-up was in a vacuum chamber in which the pressure was 200 microns. The samples had been in the chamber for at least one hour and were processed as in Section 3c within 30 minutes thereafter.

c. Strips were evaluated as in Sections 3d and 3e.

<u>Results</u>

1. Visual observation of test samples indicated no effect was produced unless the film was allowed to remain under tension over the roller. Under this condition, the film acquired a "set" which disappeared after the film was removed and set aside.

2. Under ambient conditions, a maximum variation in density of 0.06 was determined. This occurred on SO-1188 on two steps in the toe of the curve, when the film was drawn over a 1/8" diameter roller; when drawn over a 1/4" roller, this film produced a maximum density variation of 0.03.

3. Under simulated altitude conditions and drawn over a 1" diameter roller, SO-1188 produced a maximum density increase of 0.06 in the toe on two steps; SO-1221 again evidenced no significant change.

4. Since the maximum variations occurred on only a few steps, it appears that they indicate local variations.

However, since there is some variation along the entire curve for the SO-1188 over the 1/8" roller under ambient conditions and over the 1" roller under vacuum, a trend may be indicated. Extremely precise tests would be necessary to establish the extent of this effect. This variation is ordinarily considered to be within the tolerance of sensitometric determinations.

2.5.3 TESTS OF FILM DRIVE MOCK-UP IN ALTITUDE CHAMBER

2.5.3.1 Film Transport Test

A full roll of new film was installed in the supply section of the film transport mock-up. The complete assembly was placed in the altitude chamber and the pressure reduced to less than 1 mm Hg. The operating program for this test is outlined below.

1. Pressure reduced to 1 mm Hg. (Chamber pump was operated continuously throughout the complete program.)
2. Equipment allowed to soak at reduced pressure for 5 hours.
3. Film transport cycled continuously for three minutes at maximum rate followed by a two-hour soak.
4. No. 3 repeated six additional times.
5. Equipment allowed to soak for 12 hours.
6. No. 3 repeated seven times.

Comments:

1. Prior to installing supply spool, all existing tape splices were replaced with Mylar tape.
2. Film transport mock-up operated without failure throughout the complete test.
3. A full roll of film was transported through the system.
4. Film was weighed prior to the chamber test in order to determine the amount of moisture which would be out-gassed at the low pressures. The film was weighed after completion of the tests and a weight loss of approximately 1/2 lb. was noted. The roll of film was subjected to 1 mm Hg. pressure for a total time of 42 hours.

   It was noted during the test that the recording manometer on the chamber showed an increase in pressure (pump running continuously) each time the film transport was operated for the 3-minute period. This was evident even after the 5-hour and 12-hour soak periods, and to a lesser degree up to and including the final cycle period at the end of 42 hours in the chamber. This would indicate that the film when wound on the spool does not lose any appreciable amount of moisture, but the moisture loss is rapid from a single layer of film as the film is cycled through the system.

2.5.3.2 Pressure Marking Test

After the initial reliability runs, additional tests were conducted with the film drive mock-up.

The film drive mock-up provided a means of checking further and under more ideally-simulated conditions some of the film sensitivity tests previously conducted.

A projection system consisting of a 6" lens, target (aerial scene) and light source (presenting a 1-1 image) was mounted on the mock-up. The image (approximately 2-inch diameter) was focussed on the center of the platen area. The mock-up was loaded with fresh unexposed SO-1188 emulsion. The chamber was made light-tight and the pressure reduced to 1 mm Hg. The light source was controlled from outside the chamber and exposures were made on the film under simulated operating conditions.

<u>Test Results</u>

1. On the first series of tests, where only the 2" diameter scene was present on the film, the pressure marking resulting from the beaded rollers was not detected.

2. The second test series included a general fogging of the film between exposures. Pressure sensitizing of the film was observed intermittently along the edges of the film <u>only</u> in the fogged areas where the exposure was of a relatively even density throughout. The working was <u>not</u> detected in the area of the high contrast aerial scene. It was also noted that these pressure markings could be detected on undeveloped film when observed under grazing reflected light.

In all the above tests, the film was developed directly after exposure.

3. A third test was run in which the film was given a generally fogged exposure throughout the tests. Samples of this test were processed immediately after exposure. The remainder of this film is to be kept for a two-week period prior to processing to determine the effect of delayed processing on the pressure markings.

In this test, both D-19 and D-76 developer were used in immediately processing sections of the film. When the film was processed in D-19, the pressure marking was readily detected where it occurred. Using D-76 developer and developing to approximately the same density level, the effect of pressure marking was greatly diminished.

At this time the delayed processing has not been done.

All the tests were run with a nominal 1/2 lb. tension over the rollers. This pressure increases on some sections of the film during starting and stopping of the drive mechanism up to 6 lbs.

2.5.3.3 Static Tests

Some static discharge was noted in widely spaced areas and only at the edges of the film. The static was caused by the rubber drive pucks on the film spools. Static was evident only on the first two tests where the film had been re-spooled twice prior to running through the transport mock-up. On the third test, the film was re-spooled only once prior to operation and no effect of static was apparent. Conductive rubber packs are being provided on the flight unit which will reduce the possible static problem.

Additional film markings either from edge pressure or statis in re-spooling the film were noticed on the first two tests. The film was free from these density markings on the third test.

These tests indicate that a minimum amount of film handling will reduce the static problem and also any other marking that may be caused by spool edges etc. In the operational phase, there will, of course, be no handling or respooling of film until actual use.

2.6 SIMULATOR

A total of four units are being built: a static unit is completely assembled and is to be delivered to FCIC on 24 November, two identical portable field units for use by the prime whose design is nearly complete, and a dynamic unit for ITEK.

2.7 Image Motion Compensation v/h Transducer Summary

The original specification of sixteen v/h command steps required a stepping switch which was objectionably heavy. Weight of the v/h transducer has been almost halved by relaxing the specification to that shown in the following table:

Ground Command #	Transducer Output Voltage	Servo Motor Speed	% of Nominal
1	5.15	4284	60
2	6.86	5712	80
3	7.29	6069	85
4	7.72	6426	90
5	8.15	6783	95
6	8.58	7140	100
7	9.01	7497	105
8	9.44	7854	110
9	9.87	8211	115
10	10.30	8568	120
11	12.00	10000	140

The weight saving achieved by this specification change is due to (a) use of a smaller stepping switch, (b) elimination of the switch level formerly used for homing from the sixteenth position, and (c) reduction of shaft position coding levels from five to four.

3.0 Horizon Camera Alignment and Calibration

An optical device will be installed at the prime's plant for the purpose of measuring the alignment of each camera's horizon optics and the camera center of format relative to the vehicle flight axes. The prime's fixture will consist of a wall-mounted structure capable of holding the camera in flight attitude while simulating the electrical and mechanical interface between camera and vehicle. Figure 7 illustrates the layout of optical components.

Prior to mounting the camera to the wall fixture a theodolite is positioned with its axis of rotation at point A which is the intersection of the principal rays of the two horizon cameras as determined from drawings. The theodolite is adjusted parallel to the wall fixture mounting plate by mechanical or optical means, levelled with a spirit level, and depressed fifteen degrees from the horizontal.

Theodolite #2 is mounted on a pilaster with provision for translating vertically and toward the wall fixture as well as rotating in azimuth and elevation. Using theodolite #1 as a reference, theodolite #2 is positioned with its principal ray coincident with that of theodolite #1 and hence parallel to the wall mounting plate. With the addition of an illumination source behind the reticle, theodolite #2 becomes a collimated source. The same technique is employed to align theodolite #3.

Theodolite #1 is now placed in position B. Theodolite #3 is depressed sufficiently to permit aligning theodolite #1 with it, thus reestablishing theodolite #1 in the plane of theodolites #2 and #3. Theodolite #3 is then elevated to its original position and theodolite #1 is leveled with a spirit level.

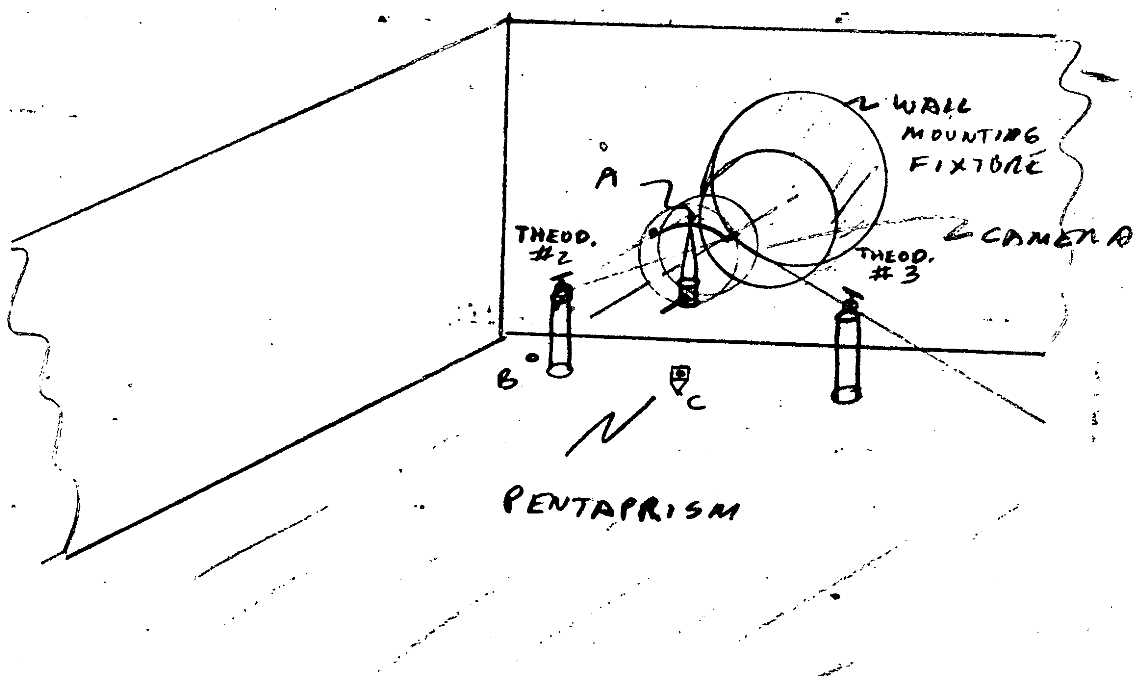


FIG 7. HORIZON-ALIGNMENT SETUP

A good quality pentaprism is now placed at position C. Surface 2 is levelled with a spirit level so that in a pitch sense it is perpendicular to the wall mounting plate. For convenience surface 2 is also levelled in the roll sense, although this alignment is not critical and indeed is the reason for using a pentaprism rather than a mirror.

A plane mirror is now placed on surface 1 so that by autocollimation this surface, which is already vertical, can be made perpendicular to the axis of theodolite #1 and hence perpendicular to the wall mounting plate. An illumination source placed behind the verticle of theodolite #1 now produces a collimated beam which is the perpendicular bisector of the angle formed by the collimated beams of theodolites #2 and #3.

The camera is now placed on the wall mounting fixture and pinned in place. With live film in the camera the two horizon camera shutters are operated and the main camera lens is swung through nadir. The film is processed and

a. the displacement of theodolite image #2 from the fiducial center of the left horizon camera

b. the displacement of theodolite image #3 from the fiducial center of the right horizon camera

c. the displacement of theodolite image #1 from the center-of-format indicator and the edge of the format.

One has the choice at this point of simply preserving the record of these data for later photogrammetric application, or adjusting the horizon cameras to reduce the displacement to a negligibly small level. Since the center-of-format indicator is fixed and in any event provides only one dimension of

4.0 Progress

4.1 Camera

The film-handling breadboard evaluation has been completed and is considered satisfactory. The main camera assembly is 60% complete and the harnessing 60% on the first unit. Progress is on schedule. Assembly of the second expendable unit will be started about 17 November 1958.

4.2 Cassette

Qualification tests have been completed. Six units have been delivered to date. The delivery of qualified units is on schedule.

4.3 Test and Checkout Console

The first unit is 100% assembled. The overall program is on schedule.

4.4 Component Tests

Component tests have been satisfactorily completed on the following units:

a. Main drive motor and tachometer assembly

b. Auxiliary lens and shutter assembly

c. A simulated lens assembly.

Component tests are underway on the following units:

a. Brakes and clutches

b. Digitate

c. Solenoids

d. Electrical breadboard of preamplifier, acceleration control, and synchronization lamp pulsing package,

e. A flight lens assembly.

4.5 Camera Test

The tower at FCIC is underway. Complete plans have been submitted. The tower is scheduled to be completed and ready for use on or before 31 Decmeber 1958. The environmental test facility will be completed by 15 December 1958.

4.6 Lens

The HYAC IIB design has been completed and glass has been ordered.

4.7 Simulator

Assembly of the first static unit has been completed. The design of the portable unit has been complete d.

5.0 SPECIAL SUPPLEMENT

This section includes a complete derivation for the image motion compensation expression. The IMC system is presently designed for a constant image compensation velocity over the target area and no yaw bias. This approach represents an acceptable compromise based on complexity, schedule and other consideration. The proper compensation value will be chosen for a position of 55° N. latitude which represents a weighted mean for which the IMC will be perfect except for the right angle component due to the excluding of a yaw bias. The assumption is also made that the orbit is not polar but inclined 15° to the equator from a southeast launch from Vandenberg AFB. This derivation will result in calculated values of V/h to be sent to the vehicle via the command link to change the IMC value in four 5-per-cent steps, above and below nominal, for a total of 20 per cent fine variation. In addition, one large step of 20 per cent is included on either end of the fine adjustment range to include capability for extremely wide variation. The calculated V/h values will be a function of orbit parameters computed from tracking data. It is assumed that altitude and latitude of perigee will be known, as well as the amount of eccentricity and inclination of the orbit plane. Tables and/or curves will be prepared to enable an operator to select a switch position based on these data. This should be an ideal arrangement from a security point of view in that the command link operator need not know that it is a camera IMC that he is controlling.

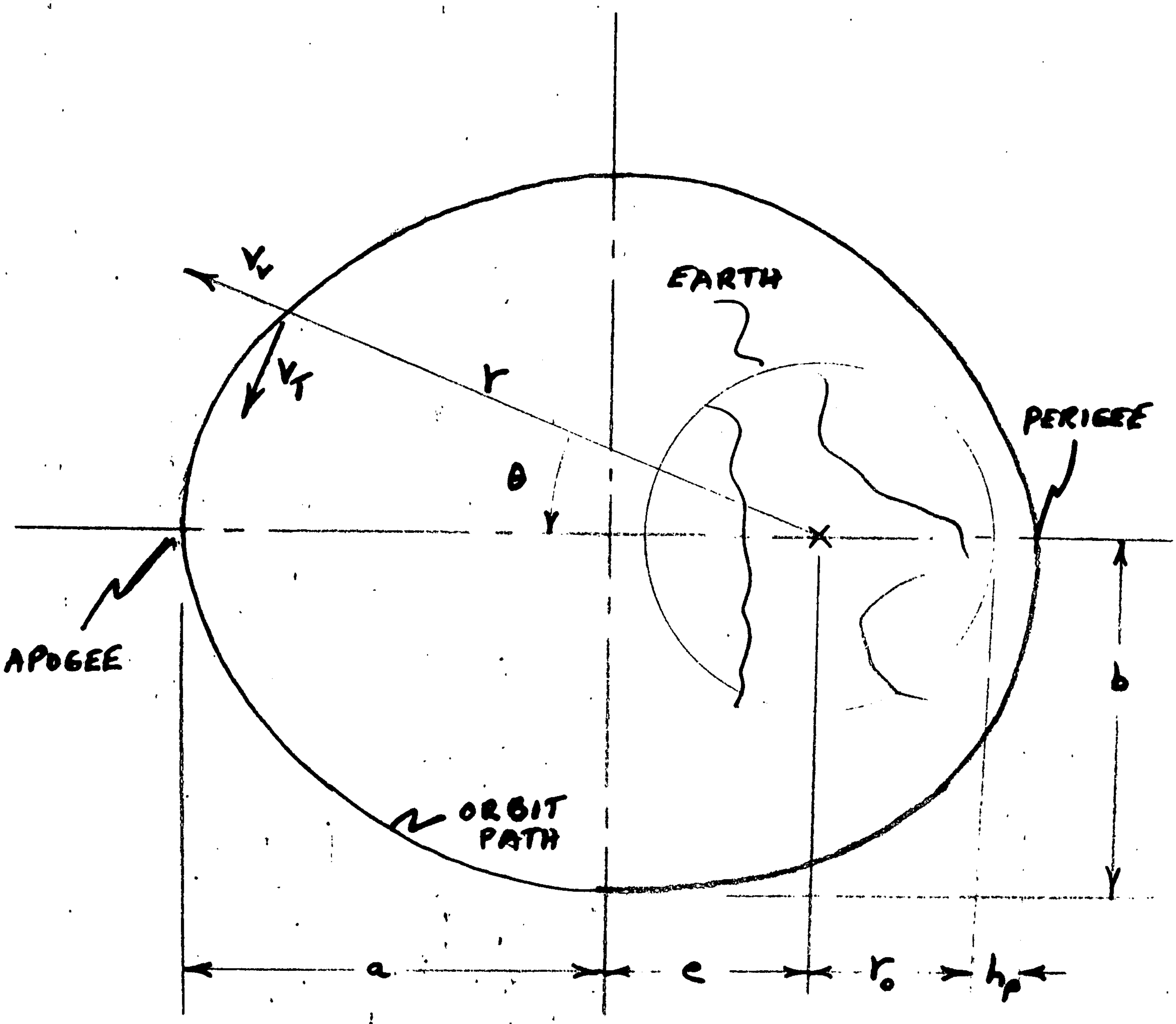


FIG. 1.1 ORBIT DIAGRAM

Section 1 Derivation of Vt/h for a Vehicle in Orbit About a Non-Rotating Earth

The motion of a body in an orbit around the earth can be obtained from Kepler's laws describing the motions of the planets around the sun. That these laws also apply to a body moving about the earth is demonstrated in Reference 2 and will not be included here. The effects of the earth's rotation on V_t/h are described in Section 2.

Kepler's first two laws applied to motion about the earth state that:

1. The orbit is an ellipse with a focus at the earth's center, and
2. The area enclosed by the orbit is swept over at constant rate by a radius from the earth's center to the orbiting body.

From the first law, the orbit must be an ellipse as shown in Fig. 1.1 for which

$$\frac{b^2}{a - e\cos\theta} \tag{1.1}$$

If eccentricity is defined as

$$\epsilon \triangleq \frac{e}{a}, \tag{1.2}$$

$$r = \frac{b^2/a}{1 - \epsilon\cos\theta} = \frac{P}{1 - \epsilon\cos\theta} \tag{1.3}$$

where P is the "parameter" of the ellipse.

The differential area swept out by r is shown in Fig. 1.2.

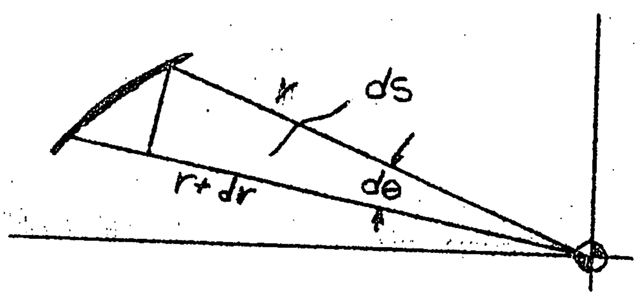


Fig. 1.2 Area swept out by the radius.

From Kepler's second law,

$$\frac{ds}{dt} = K, \text{ A CONSTANT.} \qquad (1.4)$$

$$ds = \frac{1}{2}(r+dr)\,r \sin d\theta = \frac{1}{2}(r+dr)\,r\,d\theta \qquad (1.5a)$$

OR $$ds = \frac{1}{2} r^2 d\theta \qquad (1.5b)$$

since 1/2rdrdθ is negligible compared to $1/2r^2d\theta$. Therefore,

$$\frac{ds}{dt} = \frac{1}{2} r^2 \frac{d\theta}{dt} = K \qquad (1.6)$$

It remains to find a link between eqs. 1.3 and 1.6. This can be done as follows.

In cylindrical coordinates, the radial acceleration,

$$a_r = \frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2 \qquad (1.7)$$

From eq. 1.6,

$$\frac{d\theta}{dt} = \frac{2K}{r^2} \quad \text{SO THAT} \qquad (1.8a)$$

$$-r\left(\frac{d\theta}{dt}\right)^2 = -\frac{4K^2}{r^3} \qquad (1.8b)$$

$$\frac{dr}{dt} = \frac{dr}{d\theta} \cdot \frac{d\theta}{dt} = \frac{dr}{d\theta} \cdot \frac{2K}{r^2} = -2K \frac{d}{d\theta}\left(\frac{1}{r}\right) \qquad (1.9)$$

$$\frac{d^2r}{dt^2} = \frac{d}{dt}\left(\frac{dr}{dt}\right) = \frac{d}{d\theta}\left(\frac{dr}{dt}\right)\frac{d\theta}{dt} = \frac{2K}{r^2}\frac{d}{d\theta}\left[-2K\frac{d}{d\theta}\left(\frac{1}{r}\right)\right] \qquad (1.10a)$$

or

$$\frac{d^2r}{dt^2} = -\frac{4K^2}{r^2}\frac{d^2}{d\theta^2}\left(\frac{1}{r}\right) \qquad (1.10b)$$

From eq. 1.3,

$$\frac{1}{r} = \frac{1}{P} - \frac{\epsilon}{P}\cos\theta \tag{1.11}$$

Since P is constant,

$$\frac{d}{d\theta}\left(\frac{1}{r}\right) = \frac{\epsilon}{P}\sin\theta \; ; \quad \frac{d^2}{d\theta^2}\left(\frac{1}{r}\right) = \frac{\epsilon}{P}\cos\theta \tag{1.12}$$

Combining 1.11 and 1.12,

$$\frac{d^2}{d\theta^2}\left(\frac{1}{r}\right) = \frac{1}{P} - \frac{1}{r} \tag{1.13}$$

so that eq. 1.10b becomes

$$\frac{d^2r}{dt^2} = \frac{4K^2}{r^2}\left(\frac{1}{r} - \frac{1}{P}\right) \tag{1.14}$$

and

$$a_r = -\frac{4K^2}{Pr^2} \tag{1.15}$$

But, from Newton's law of gravitational attractions

$$a_r = -g_P \frac{(r_0 + h_P)^2}{r^2} \tag{1.16}$$

Setting 1.16 equal to 1.15 yields the desired relation that

$$P = \frac{4K^2}{g_P (r_0 + h_P)^2} \tag{1.17}$$

At this point, it will be helpful to define the constant

$$\mu = g_o r_o^2 = g_p (r_o + h_p)^2 \tag{1.18}$$

where g_o is the gravitational acceleration at r_o, the earth's mean radius. Eq. 1.17 then becomes

$$P = \frac{4K^2}{\mu} \tag{1.19}$$

and, with eq. 1.3,

$$r = \frac{4K^2}{\mu(1 - \epsilon \cos\theta)} \tag{1.20}$$

To determine the constant K, assume a horizontal injection into orbit so that $r = r_o + h_p$ at θ (angle-to-appogee) = 180°.

Eq. 1.20 now becomes

$$r = r_o + h_p = \frac{4K^2}{\mu(1+\epsilon)} \tag{1.21a}$$

or

$$K = \frac{1}{2}\mu^{1/2}(h_p + r_o)^{1/2}(1+\epsilon)^{1/2} \tag{1.21b}$$

Since K is constant throughout the orbit,

$$r = \frac{(h_p + r_o)(1+\epsilon)}{1 - \epsilon \cos\theta} \tag{1.22}$$

The altitude can be found from eq. 1.22 by referring to Fig. 1.1 where $h = r - r_o$. Thus,

$$h = \frac{h_p(1+\epsilon) + \epsilon r_o(1+\cos\theta)}{1-\epsilon\cos\theta} \tag{1.23}$$

The velocity of interest to the IMC system is the component parallel to the surface of the earth. This component is labeled V_t on Fig. 1.1 and is given by

$$V_T = r\frac{d\theta}{dt} \tag{1.24}$$

Substitution of eqs. 1.8a and 1.22 into eq. 1.24 gives

$$V_T = \left[\frac{\mu}{(h_p+r_o)(1+\epsilon)}\right]^{1/2}(1-\epsilon\cos\theta) \tag{1.25}$$

$\frac{V_t}{h}$ for a non-rotating earth is just 1.25 divided by 1.23 or

$$\boxed{\left[\frac{V_T}{h}\right]_{\text{NON-ROTATING}} = \left[\frac{\mu}{(h_p+r_o)(1+\epsilon)}\right]^{1/2}\frac{(1-\epsilon\cos\theta)^2}{\left[h_p(1+\epsilon)+\epsilon r_o(1+\cos\theta)\right]}} \tag{1.26}$$

To the above expression for $\frac{V_t}{h}$ must be added a component due to the earth's rotation. This component, $\left[\frac{V_t}{h}\right]_{rot}$, is obtained in the following section.

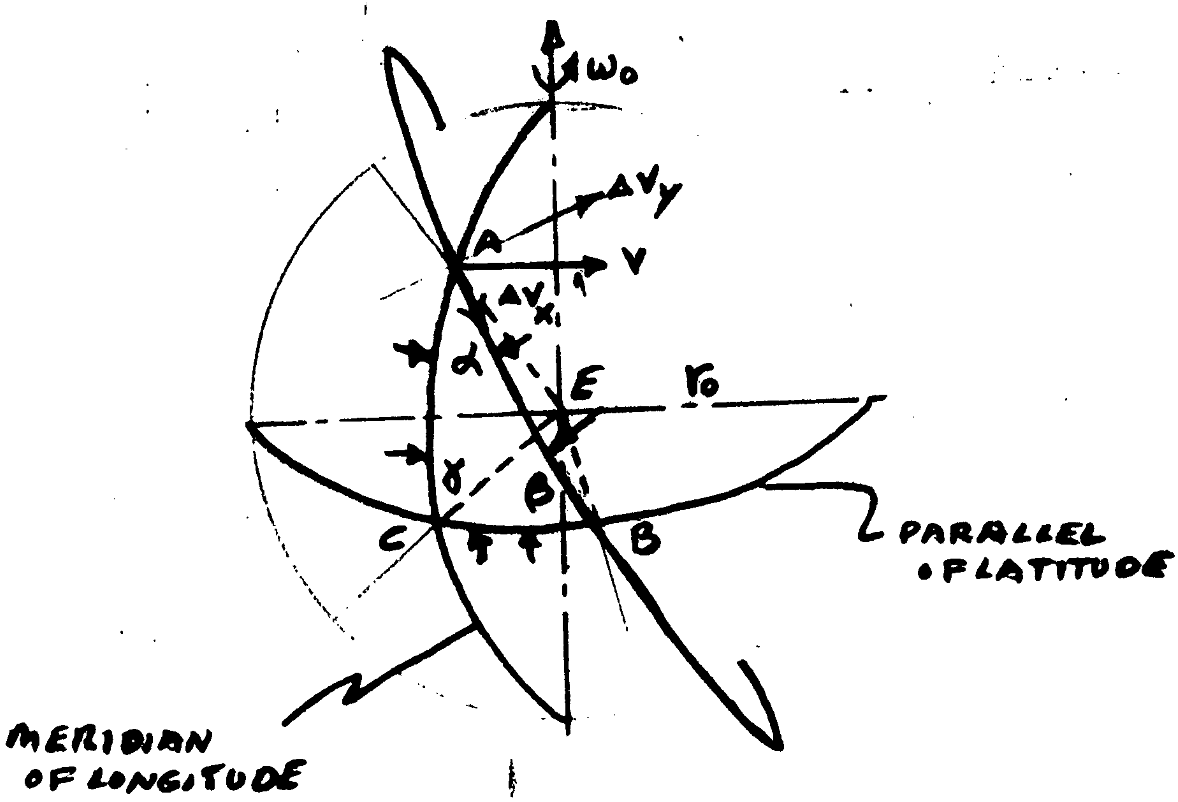


FIG. 2.1 EARTH ORBIT

Section 2. The Effect of Earth Rotation on V_t/h

The main effect of earth rotation is to change the direction and magnitude of the relative velocity vector between the camera and ground. As will be shown below, this effect can be considered as a small change in orbital velocity along with an effective angle of yaw.

Consider an inclined orbit as shown in Fig. 2.1. The components of earth tangential velocity resolved along, and normal to, the orbit are given by

$$\Delta V_y = V\cos\alpha \tag{2.1}$$

$$\Delta V_x = V\sin\alpha \tag{2.2}$$

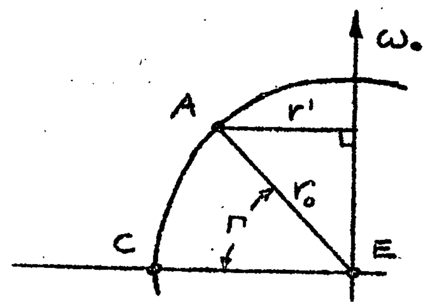


Fig. 2.2

Looking at a section taken through AC shown in Fig. 2.2, and noting that

$$V = r'\omega_0 \tag{2.3}$$

eqs. 2.1 and 2.2 become

$$\Delta V_y = r_0\,\omega_0 \cos\Gamma \cos\alpha \tag{2.4}$$

$$\Delta V_x = r_0\,\omega_0 \cos\Gamma \sin\alpha \tag{2.5}$$

Since AC lies along a line of constant longitude and CB lies along a line of constant latitude, ABC is a right spherical triangle for which

$$\sin \alpha = \frac{\cos \beta}{\cos \Gamma} \qquad (2.6)$$

Combining eq. 2.6 with eqs. 2.5 and 2.6 gives the desired expressions for ΔV_y and ΔV_x.

$$\Delta V_y = r_o \omega_o \cos \Gamma \cos \left[\sin^{-1} \left(\frac{\cos \beta}{\cos \Gamma} \right) \right] \qquad (2.7)$$

$$\Delta V_x = r_o \omega_o \cos \beta \qquad (2.8)$$

where

β = inclination of the orbit from equator.
Γ = Latitude
ω_o = earth rotational rate = 7.2921159×10^{-5} $\frac{\text{RAD}}{\text{SEC}}$
r_o = earth mean radius = 20,888,104 Ft

Note that ΔV_x is constant along the orbit, depending only on the orbital inclination.

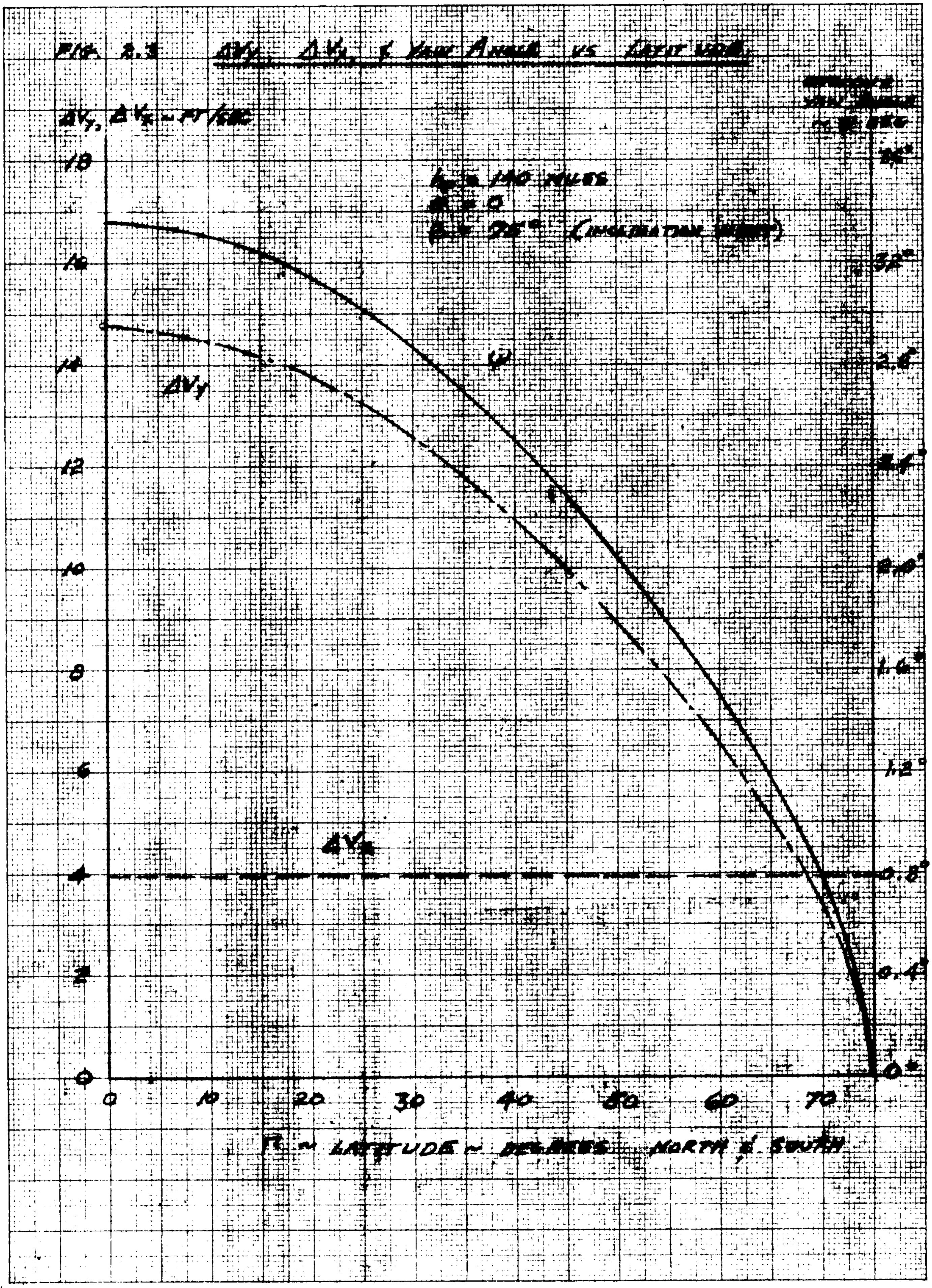
For a southeast launch direction as shown in Fig. 2.1, ΔV_x will tend to reduce the relative velocity between camera and ground. ΔV_y will act in such a manner that the vehicle will have an apparent yaw angle to the east, given by

$$\psi = \tan^{-1} \left(\frac{\Delta V_y}{V_o - \Delta V_x} \right) \qquad (2.9)$$

where ψ = yaw angle
V_o = orbital velocity component parallel to earth's surface.

In order that the IMC compensate for all the relative motion between the vehicle and earth, the vehicle must be yawed ψ degrees to the west by its attitude control system. A plot of ΔV_y°, ΔV_x, and ψ as functions of latitude is presented in Fig. 2.3 for the following orbit.

V_o = 25,498.7 Ft/Sec
β = 75° from West
ϵ = eccentricity = 0 (circular orbit)


18
16
14
12
10
8
6
4
2
0
ΔV_y
ΔV_z
0
10
20
30
40
50
60
70
LATITUDE ~ DEGREES NORTH & SOUTH
0.4°
0.8°
1.2°
1.6°
2.0°
2.4°
2.8°
3.2°

Section 3. V_t/h Compensation Charts

It has been shown in previous sections that V_t/h is dependent on a number of parameters. Some of these parameters, such as orbital inclination and target-angle-from-apogee, can be predicted with certainty prior to launch. Other parameters, however, are both first order in their effects, and cannot be predicted with a sufficient degree of certainty. These parameters are eccentricity of the orbit and injection altitude.

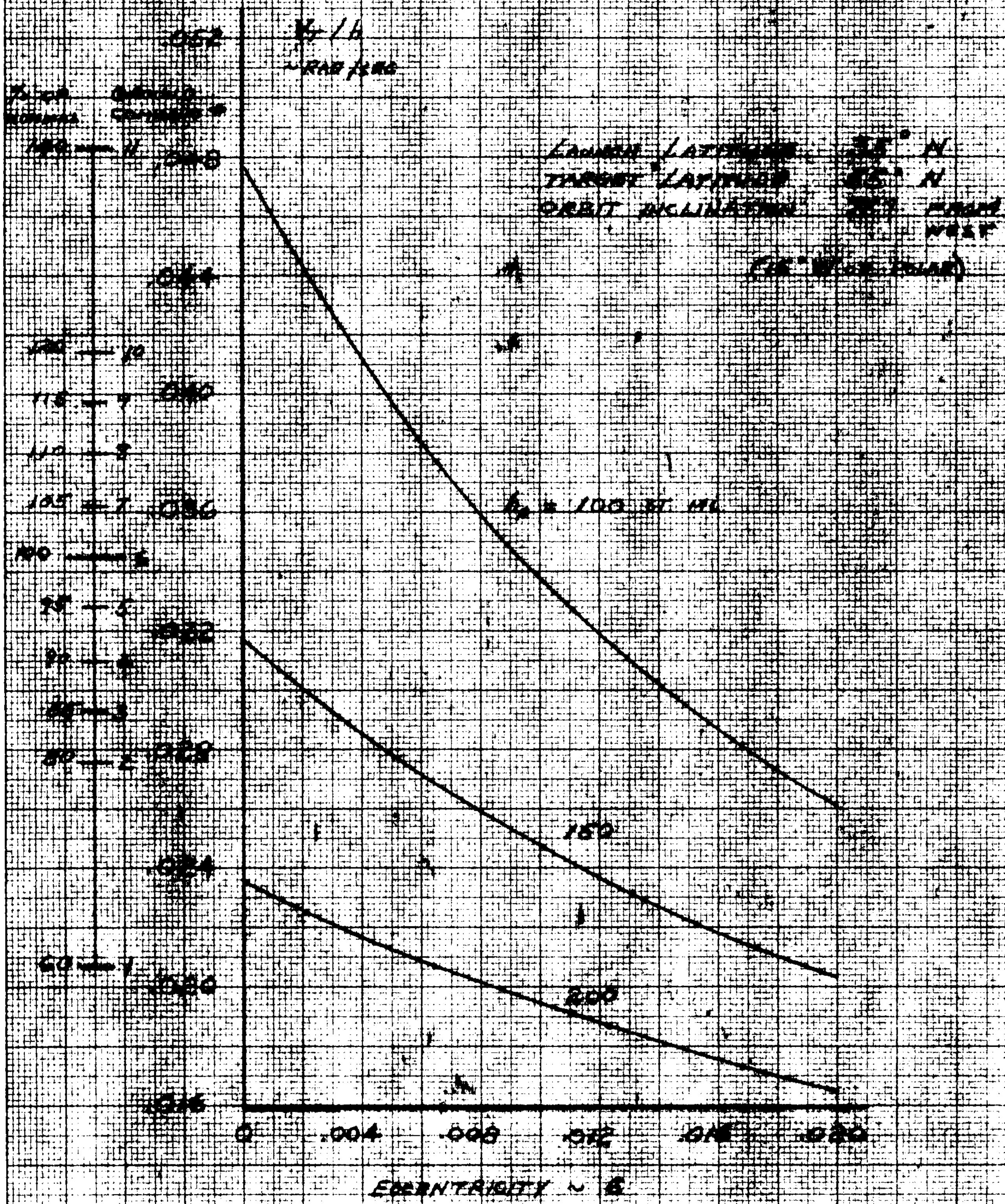
It is therefore planned that charts be prepared giving V_t/h as a function of ϵ and h_p. Each chart will be for fixed values of the more predictable variables β and θ. Once ϵ and h_p are known from tracking data, a V_t/h command signal can be quickly determined and transmitted to the IMC system.

A typical chart* is shown in Fig. 3.1 for an orbit inclined 75° from west (15° west of a polar orbit) with a target latitude of 55° N and an injection latitude of 35° N.

---

* The final charts will include altitude increments of 5 or 10 miles rather than the 50-mile increments shown in Fig. 3.1. Time did not permit the calculating of the smaller increments during this report period.

FIG 3.1 V_T/h COMPENSATION CHART



ITEK Corporation
Boston and Waltham, Massachusetts

31 October 1958

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1. Prigge, J.S.; Parsons, T.E.; and Berman, L. J., A Digital Computer Study of the Powered-Flight Trajectories of Long-Range Ballistic Missiles, Aerophysics Research Group Report ARG R-1, Aeronautical Engineering Dept., M.I.T., Cambridge, Mass. December 1956.

2. Rauscher, Manfred, Introduction to Aeronautical Dynamics, John Wiley and Sons, Inc., New York, 1953.

FAIRCHILD
CAMERA AND INSTRUMENT
CORPORATION

DEFENSE PRODUCTS DIVISION
300 ROBBINS LANE • SYOSSET, LONG ISLAND, NEW YORK

10 October 1958

Refer: SC-20

Itek Corporation
700 Commonwealth Avenue
Boston 15, Massachusetts

Attention: [redacted] STAT

Subject: Letter Subcontract dated 5 May 1958

Enclosures: I Eleven copies of Progress Report No. 4

II Eleven copies of Fiscal Report for the period ending 30 September 1958

Gentlemen:

Enclosures I and II covering our performance under the subject order for the period ending 30 September 1958 are forwarded herewith in accordance with the requirements of your subcontract.

The following are our estimates of completion in the categories requested by you in your letter of 31 July 1958:

Time Span	26%
Man Hours	24%
Dollars	26%
Physical completion of equipment	25%

We trust the above will satisfy your requirements.

Very truly yours,

FAIRCHILD CAMERA AND INSTRUMENT CORPORATION
Defense Products Division

[redacted] STAT

GJS/rcg
Enclosures

Enclosure I

8 October 1958

Project Stovepipe

Progress Report No. 4

1 September 1958 thru 30 September 1958

General

The major effort on this program during the reporting period has been directed towards completion of the design of all units, improvement of breadboard performance and fabrication of final parts and components. Final information from our debugging effort of breadboards has permitted the completion of design and detailing in the camera area. Release of all items for fabrication can now be estimated as 98 percent complete. The overall estimated completion of the program is 25 percent.

A general status review of the program with the customer early this month concluded with a delivery schedule change affording Fairchild approximately a one month delay. This change by the Prime Contractor afforded us considerable relief in our effort during this reporting period.

Additional changes in scope have also been received from the customer this month which will unavoidably affect delivery of initial units. Temperature telemetering component requirements have only been finalized late this month causing a delay in design and changes in parts released for fabrication. Thermal isolation of the camera's main mounting plate has been investigated and the necessary design and fabrication changes have been evaluated as to their affect upon camera delivery. A decision, by the customer, has not been received to institute this change in the camera at this reporting date so that a delay in delivery of the first affected unit will be further compounded when we are given a go-ahead in this area.

Information concerning design of the camera to vehicle light sealing has been very slow in being finalized by the Prime Contractor. This has only affected the release of a few items for fabrication but any extended delay can affect the initial camera delivery.

I. Camera Detailed Progress

A. Breadboard Testing

1. Film Handling Breadboard

A redesign of the breadboard skew rollers and extensive testing in order to evaluate their performance has been accomplished this month. As anticipated, the film handling characteristics of the new beaded rollers was found to be extremely reliable. A minimum of 10 full rolls of dummy film was transported under conditions of simulated programming in the laboratory without any failures. Pressure marking of the film was still found to be objectionable with this new beaded roller design when film tensions exceeded one pound while transporting over them. This marking of course was found to be much more noticeable over a format of uniform density compared to one of varying contrast such as can be found on a normal photograph. Apparently the contrast of objects on a normal photograph is instrumental in making this marking less definable.

Present efforts are now underway to modify the breadboard for operation at a constant supply tension of under one pound. It is felt that this change can be incorporated in the present camera design with minimum effort and that the resultant pressure marking will no longer be objectionable. Breadboard modifications and camera redesign are preceeding as a parallel efforts.

2. Lens Drive Breadboard

The redesigned lens drive incorporating a single bi-directional Saganaw Screw has been extensively debugged and tested. The latest results indicate a maximum velocity ripple of 2-1/2% - 0 to peak. We feel that we have approached an ultimate in improving this type of drive and that operation in the final camera will be satisfactory. Many of the items in the breadboard have been accurately duplicated in the final design. Alignment and assembly techniques have been developed and will be very useful in debugging the final camera mechanism. At present there is a reliability investigation proceeding on the Autotronic clutches and brakes used on this drive. Tests are being run in the small altitude chamber to determine the expectant life of these units. The final servo drive components have been incorporated in this breadboard and all items have been operating satisfactorily. It also appears that our velocity ripple decreased slightly after these items were used.

The straight gear drive design for use as a back-up in breadboarding has been completed. All items are being detailed and will be released next month for fabrication. This effort was unavoidably delayed due to some of the recent added tasks to which design effort was diverted.

3. Curved Platen Breadboard

Titanium platens with a Honeycomb core have been fabricated with satisfactory results. It was found that this component can be pressed to an accuracy of about .007" on the radius of a curvature. In order to assure dimensional stability of these platens after machining the addition of light weight Honeycomb side plates was made.

A modification of the final construction was made on a breadboard platen. After machining it was found that the ground curvature remained true to within .002". It is therefore felt that the more conservative final design will be structurally superior in maintaining the machined accuracy of the focal plane.

A technique for applying a platen finish to the shutter has been developed. We have found a satisfactory paint finish that can be applied uniformly to Titanium with an approximate buildup of .00015". This finish has been applied to our simulated platen in the film handling breadboard and is being evaluated for wear.

4. Stovepipe Breadboard

A breadboard of the actual stovepipe to be used in the final camera was made to prove out fabrication technique. This unit utilized a four piece construction of .002" Titanium skin Honeycomb plate which were mitered and bonded together. Excess weight was removed from the plates by routing out areas through one wall and core only. A static deflection test proved this construction to be sufficiently rigid for its intended use.

B. Design and Fabrication Effort

1. Final fabrication effort is now approximately 25% completed on the entire camera program. Many subassemblies have been completed. These included many of the film handling rollers and shaft assembly. Final Honeycomb mechanism plates have been fabricated and are now being machined. Other significant mechanical items such as platens, stovepipe and lens drive mechanism are expected to be completed in early October. Transit cases for the camera are presently being designed by Skydyne Incorporated, Port Jarvis, New York. The design will be completed early next month and first units will be received during November.

There are no major items which at this moment are presenting fabrication or schedule difficulties.

2. Scan Rate Control

Final selection of circuit components in the scan drive preamplifier has been made to obtain optimum servo response, stability and accuracy. Velocity servo data system voltages have been specified.

Heat runs at altitude have been continued on the power transistors used to supply the scan drive motor. These tests have been made under simulated load and heat sink conditions.

A programming circuit for controlling the limits of travel of the stovepipe as a function of V/H signal, has been satisfactorily breadboarded. This circuit has been added to the accelerating control package and released for fabrication.

3. Data Recording Illumination Supplies

The lamp pulsing supply package has been designed and released for fabrication. This package includes the synchronized illumination pulsing supply for the digital timer and the frequency recording power supply.

The fiducial lamp excitation circuitry has been modified to provide for parallel connection of lamps in order to obtain greater reliability. Exposure tests on films of various emulsion speeds have been continuing on the frequency, digital timing, and fiducial illumination systems.

Time Totalizer

The excitation requirements of the "Digitote" electromechanical timer and frequency recording lamps have been determined to specify the output requirements of the time totalizer.

Engineering on the time totalizer is proceeding. Quotations on a frequency standard have been received. Standard miniature packages for the frequency division circuits have been procured and satisfactorily tested. Output pulsing circuits are being breadboarded.

4. General Electrical Controls

The breadboards of the scan drive preamplifier, accelerating and programmed switching amplifier, and lamp pulsing supply are being environmentally tested to evaulate the circuit components prior to assembly in completed packages.

A number of the control panels for mounting accessary relays resistors, capacitors etc., have been designed and released for fabrication. The remainder of these panels which mount temperature telemetering components, for which information has only recently been received from the customer, will shortly be designed and released for fabrication.

The main camera schematic diagram has been kept up to date with changes dictated by current breadboard testing and customer requirements. A harnessing diagram is in the process of preparation and will shortly be completed.

C. Final Delivery

The delivery of film spools to the customer was completed on schedule during this month. A total of 115 spools have been shipped.

D. Future

Efforts in debugging and improving performance of breadboards will continue. Component tests on items as they are available will be made. Fabrication of all camera components will continue and major assemblies will be completed by the end of the month.

II. Cassette Detailed Progress

A. Breadboards

1. Tests of the spiral bevel gear drive were completed on the film drive breadboard. The spiral bevel gear drive method has been adopted for the cassette.

B. Qualification Testing

1. Qualification testing of a complete cassette was begun during the latter part of September. The vibration and shock tests were completed. The only failure was a broken lead in the film footage potentiometer during the shock test. However, the potentiometer was not the potted unit which will be included in all qualified units but a standard model which was on hand. The potted units had not been received when the qualification tests began.

C. Shop Releases

1. Shop releases have been made for the full quantity of twenty four cassettes.

D. Deliveries

During September three unqualified test cassettes were delivered on schedule.

E. Future

During October qualification testing is scheduled to be completed. It is expected that deliveries of test and qualified units will continue on schedule.

III. Console and Test Fixture Detailed Progress

A. Test Fixtures

Design completed on Camera Test Fixture, 956-T8 and Camera-Cassette Test Fixture, 956-T3. Shop releases made on four (4) camera test fixtures and one (1) camera- cassette test fixture. Shop releases made on five (5) simulated cassettes, 956-T5 and four (4) cassette test fixtures and film metering supply, 956-T12. One each of assemblies 956-T5 and 956-T12 have been delivered and are now in use. Fabrication on seven (7) camera holding fixtures, 956-T2 50% complete. Design started last week of this reporting period on three (3) new tasks, (a) the collimating test fixture for Horizon Recording cameras, (b) the 45° mirror for "Picture Taking" with the Camera-Cassette test fixture and (c) the film spool handling fixture, 956-T43.

B. FCIC Test Equipment

Fabrication and test of four (4) simulated vehicle clocks, 956-T23, 75% accomplished. Fabrication and debugging of four (4) command and control test fixtures, 956-T29, 80% complete.

C. Test Consoles

Console frame assemblies and long lead items such as Recorders and Power Supplies received and design modifications to same being frozen. Release of about 10% of the modifications have been made. Control Panel design completed; expect release for fabrication second week of October. Transit case design underway by Skydyne; expect design drawings to be available for approval first week of October.

D. Future

Assembly and fabrication will continue in all areas of consoles and test fixtures.

M # 27784

Letter Subc...
CONTRACT # dated 5 May 1958

MONTHLY FISCAL REPORT

JOB # 3596-70

CUSTOMER Itek Corp.

DATE 9/10/58

CONTRACT ESTIMATED COST ______ FIXED FEE ______ TOTAL $1,000,000.00

ITEM	EXPENDITURES AT 9/30/58	OPEN COMMITMENT AT 9/30/58	TOTAL EXPENDITURES & COMMITMENTS AT 9/30/58	ESTIMATE TO COMPLETE	TOTAL ESTIMATE COST AT COMPLETION
Engineering Labor	$ 174,580.78	$	$ 174,580.78		
Engineering Overhead	213,295.38		213,295.38		
Factory Labor	20,222.83		20,222.83		
Factory Overhead	34,361.30		34,361.30		
Material & Sub-Contract	92,724.34	100,126.60	192,850.94		
Travel & Subsistence					
Other					
Total Manufacturing Costs	$ 535,184.63	$ 100,126.60	$ 635,311.23		
G & A @ 15%	80,277.69	15,018.99	95,296.68		
Total Costs	$ 615,462.32	$ 115,145.59	$ 730,607.91		
Fee	--	--	--		
TOTAL	$ 615,462.32	$ 115,145.59	$ 730,607.91		

Classification Code No.	Classification	Hours thru 30 September 1958
51	Program Chief	753
85	Senior Research Engineer	888
180	Program Director	183
212	Electrician	8
301	Engineer	4,851.1
302	Engineering Technician	4,299.2
303	Engineering Aide	568.3
304	Senior Draftsman	3,700.2
305	Designer, Tool	9.5
306	Draftsman	186
307	Senior Engineer	2,032.5
308	Engineering Assistant	275.5
309	Project Engineer	3,243
311	Design Engineer	2,787
312	Designer	1,603
316	Photographer	274.6
319	Junior Draftsman	12.7
320	Product Design Leader	1,669.2
321	Product Designer	789
322	Junior Engineer	268.6
323	Senior Methods Man	46
327	Engineering Data Writer, Senior	12
330	Artist	1.5
332	Project Coordinator, Jr.	2,746.2
333	Project Coordinator	195
334	Project Coordinator, Sr.	5
335	Quality Analyst	4
338	Manufacturing Engineer	537.3
339	Assistant Photographer	656.4
349	Senior Project Engineer	2,450.5
350	Sr. Engineering Technician	2,558.5
402	Boring	638.3
403	Drill Press	401.1
404	Eng. & Bench Lathe	68.6
406	Grinding	226.3
407	Hobbing	286.4
408	Hand Screw & Broach	744.1
409	Engraving	1,083.4
411	Straightener	22.1
412	Turret Lathe	949.9
414	Honing-Burnishing - Machine	25.3
416	Mech. Assembly	28.3
419	Die Maker	53.6

Classification Code No.	Classification	Hours thru 30 September 1958
420	Toolmaker	505.1
422	Jig Borer	772.5
431	Instrument Maker	6,581.8
432	Experimental Specialist Machinist	2,641.2
435	Finisher	130.9
436	Plater	235.7
437	Power Press Operator	6.5
438	Painter	79.2
439	Heat Treater	57.5
440	Apprentice	65.9
445	Tool Inspector	27.5
446	Mech. Inspector	177.8
447	Elect. Inspector	33.4
448	Optical Inspector	44
450	Radio Technician	8
454	Asst. Test Equipment Technician	141.7
463	Experimental Inspector	834.6
466	Tumbler	6.8
467	Toolroom Specialist Machinist-Grinding	38.9
468	Toolroom Specialist Machinist-Lathe	45.1
469	Toolroom Specialist Machinist-Milling	16.1
		54,591.4